GFDL Seasonal to Decadal Predictions: Challenges and Issues

- GFDL hurricane prediction across timescales

- A new global coupled model to understand and predict the climate/weather connection: FLOR

GFDL Hurricane Prediction Across Timescales

- DAYS (GFDL Hurricane Model)
- MONTHS (HiRAM 25km Seasonal Forecasts)
- SEASONS (HyHuFS Hybrid Forecast System)
- YEARS (Decadal HyHuFS)
- DECADES & CENTURY

GFDL Hurricane Prediction Across Timescales

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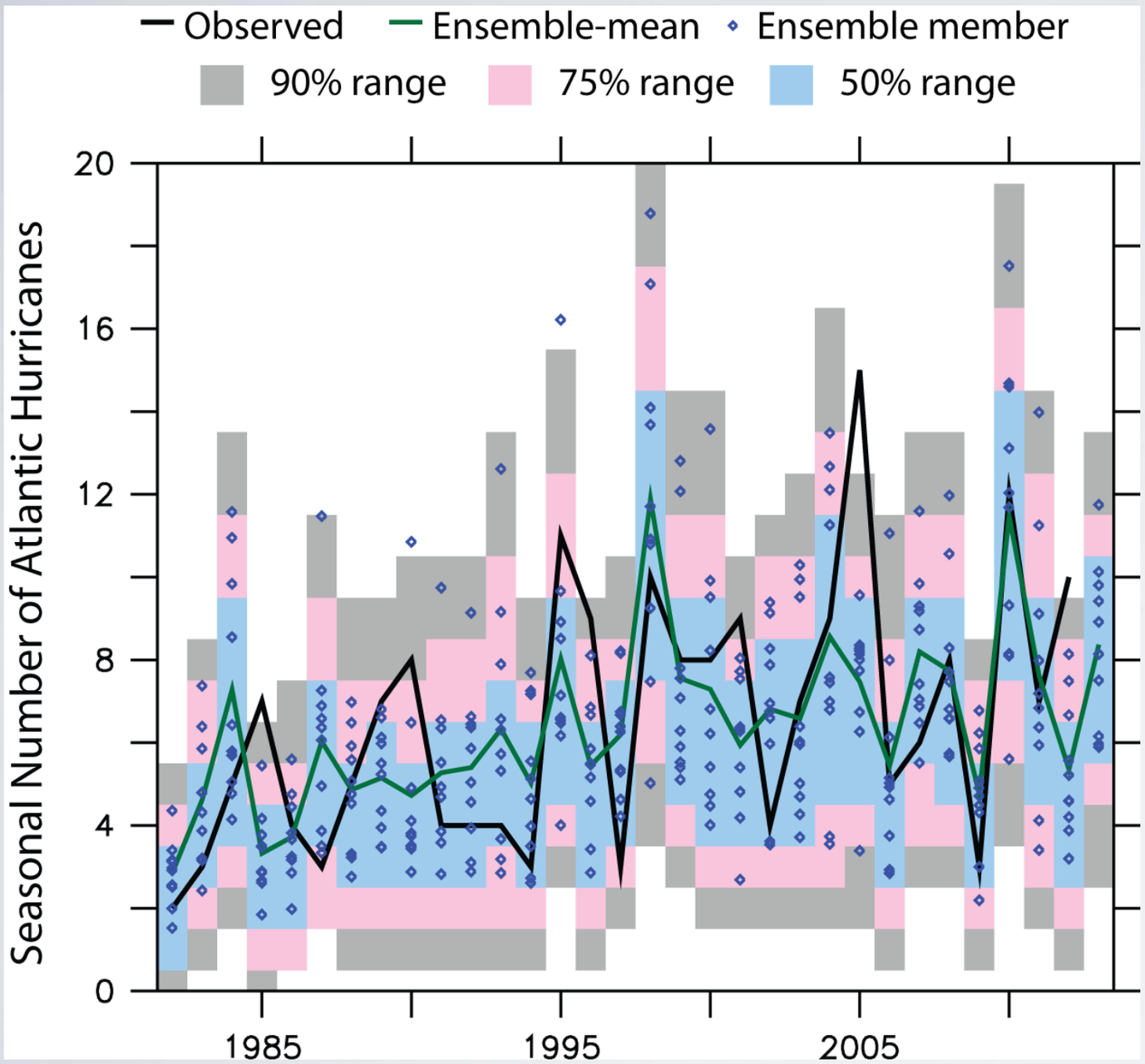
Predictions

HyHuFS long-lead forecasts system.
Some skill from as early as October of year before



Initialized 1-March

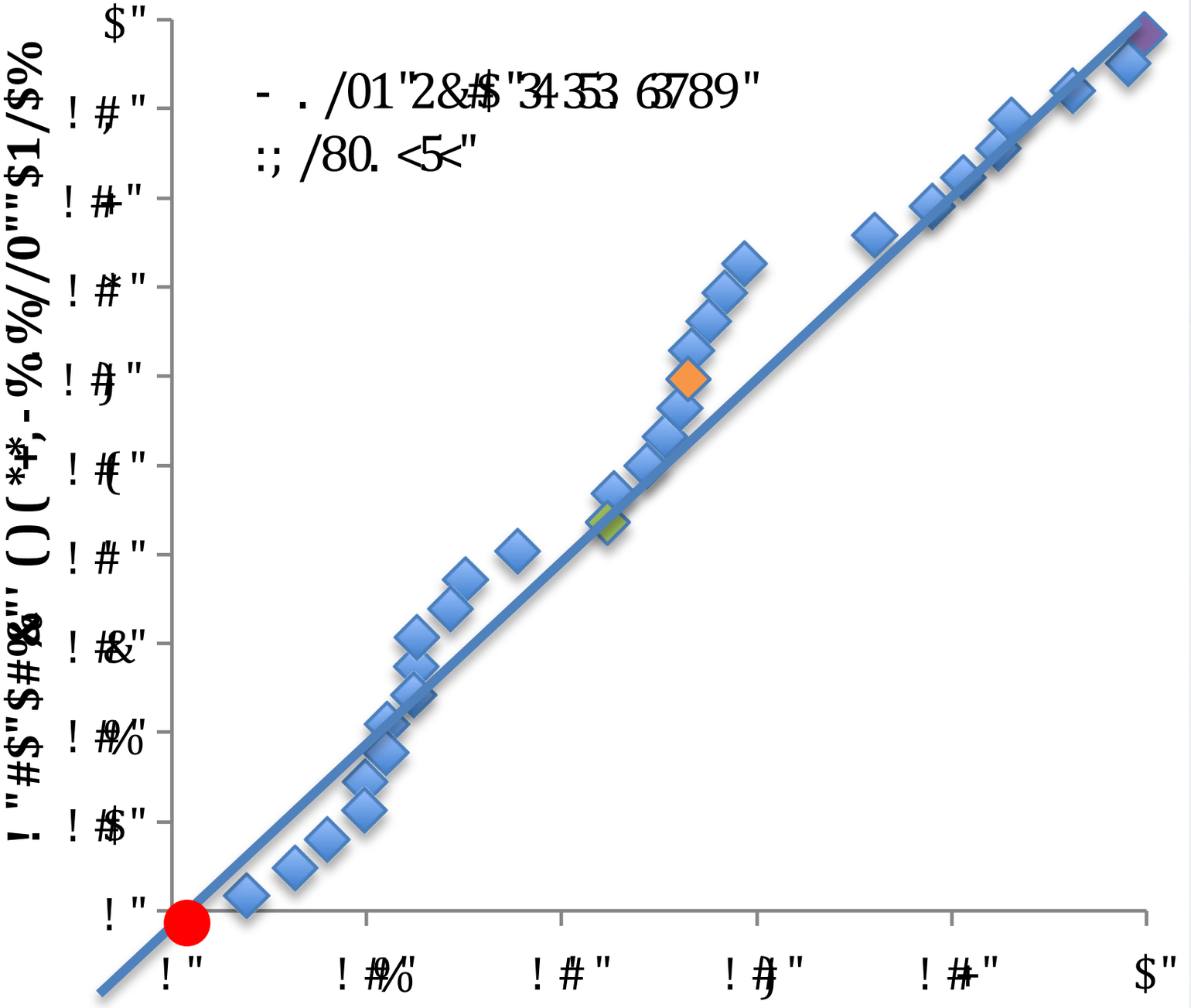
May & onward forecasts fed to NOAA Seasonal Outlook Team

Ongoing effort to apply to all NMME models

http://gfdl.noaa.gov/HyHuFS

Vecchi et al. (2011), Villarini and Vecchi (2013)

Prediction PDF Appears Relatively Well Calibrated



Blue: prior to publication of method

Colors: post-publication (2010-2012)

If 2013 ends now.

YEARS: 5-year hurricane predictions

Hybrid system: statistical hurricanes, dynamical decadal climate forecasts

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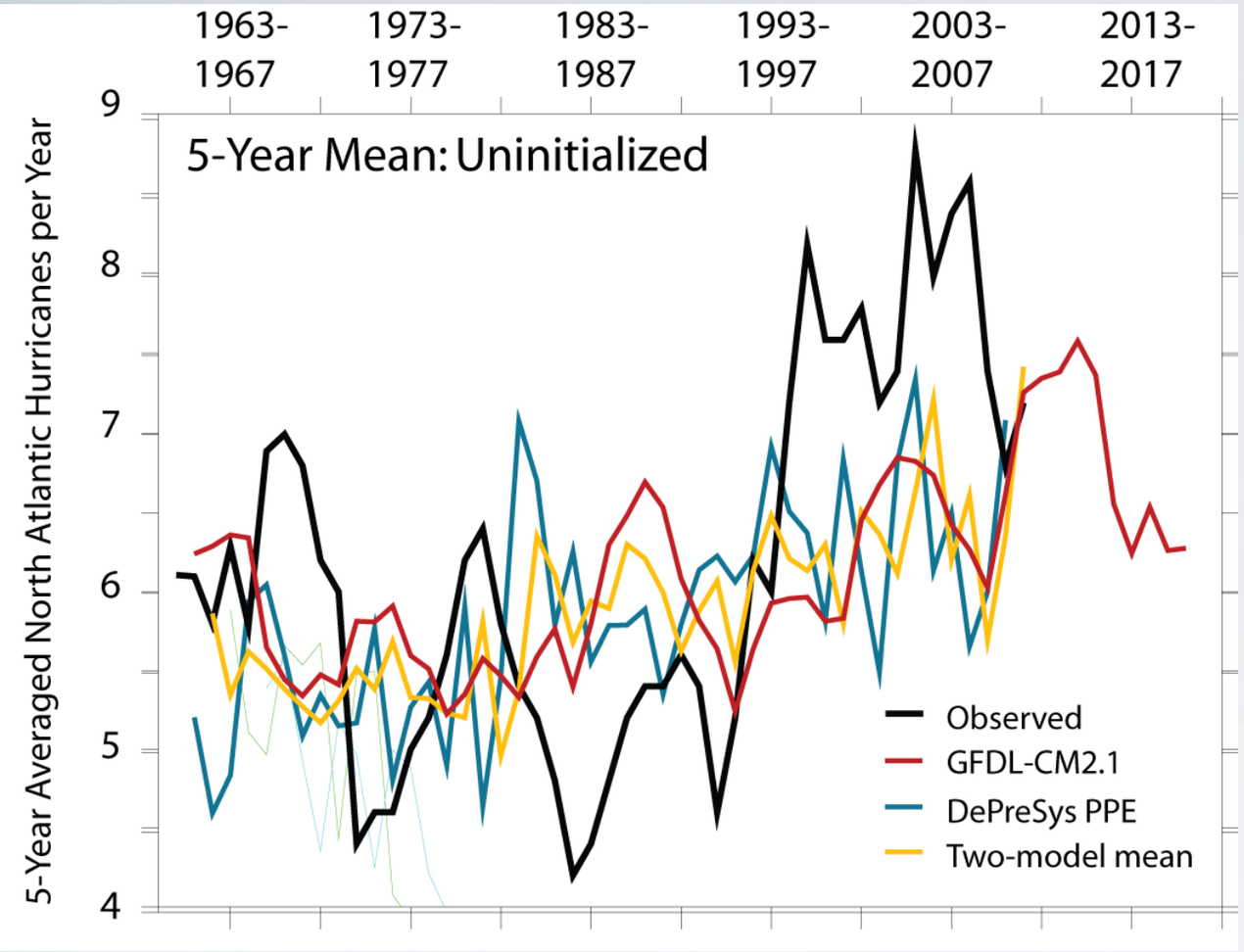
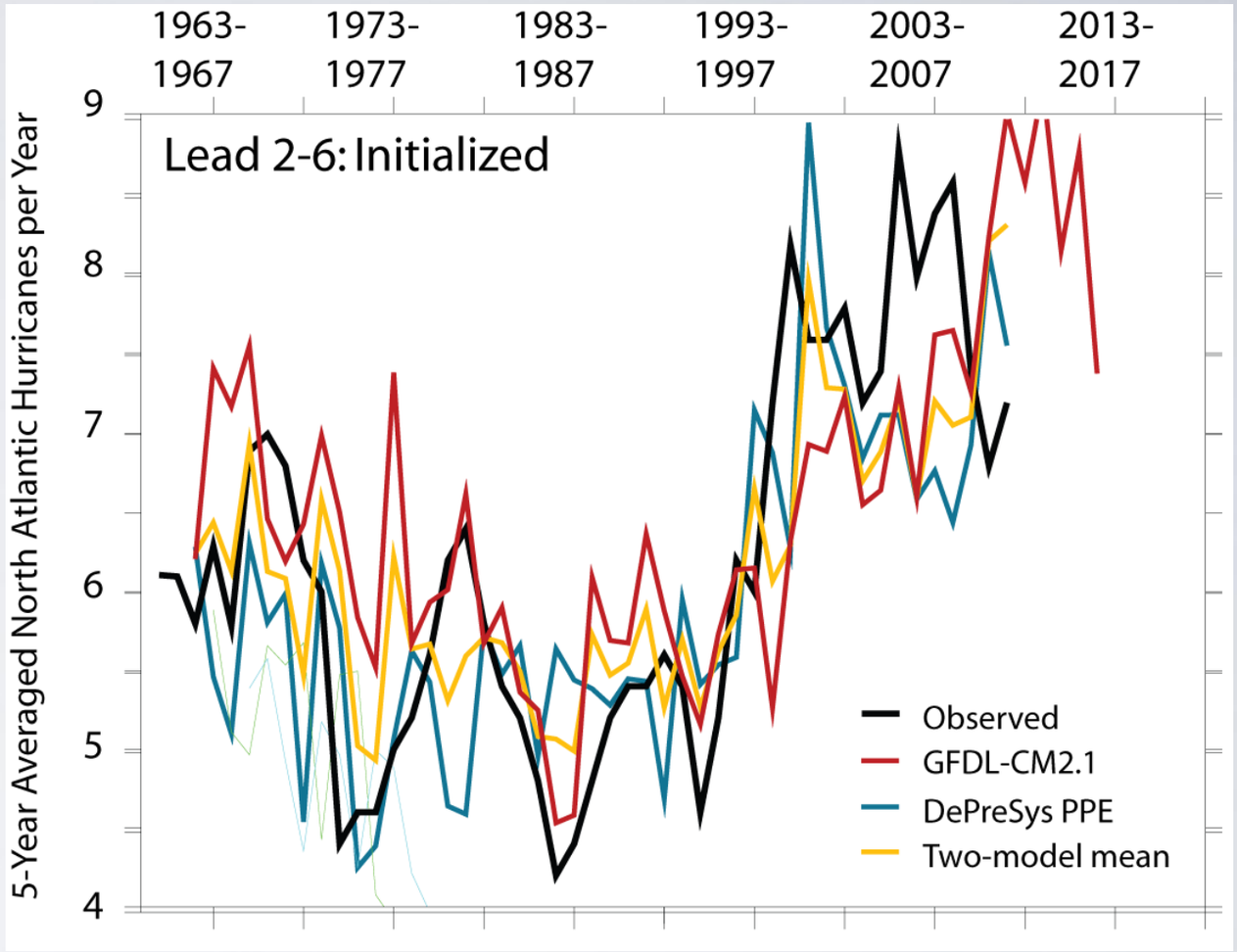
FORCED & INTIALIZED





- Retrospective predictions encouraging.
- However, very small sample size limits confidence
- Skill arises more from recognizing 1994-1995 shift than actually predicting it.

EXPERIMENTAL: NOT OFFICIAL FORECAST

Vecchi et al. (2013.a, J. Clim.)

Impact of Resolution on Simulation and Prediction

Hypothesis: Enhanced resolution will lead to improved simulation and prediction of climate.

Goal: Build a seasonal to decadal forecasting system to:
Yield improved forecasts of large-scale climate
Enable forecasts of regional climate and extremes

High Resolution Coupled Model Development

Scientific Goals:

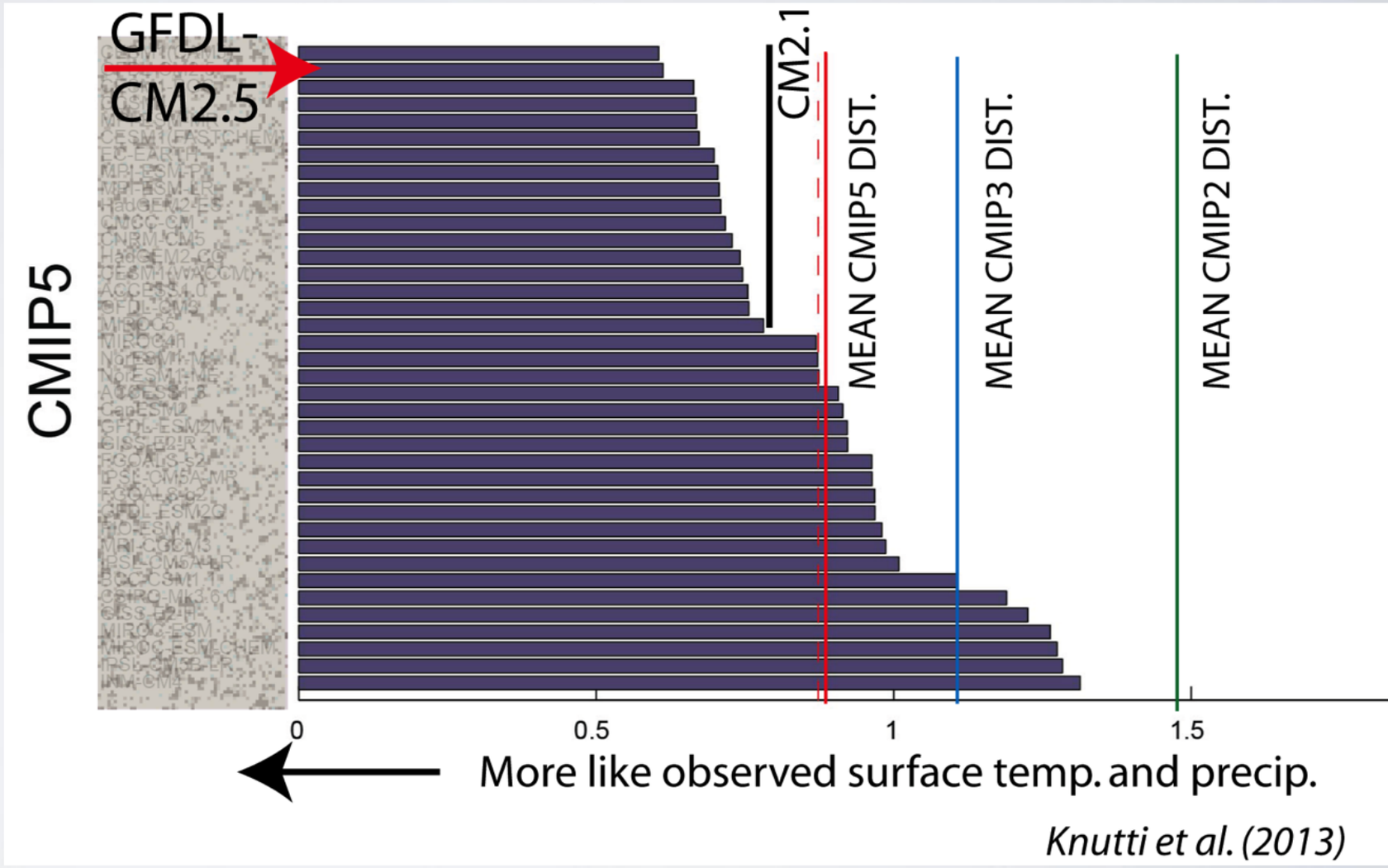
- **Develop improved models (higher resolution, improved physics and numerics, reduced bias) for studies of variability and predictability on intra-seasonal to decadal time scales**
- **Explore impact of atmosphere and ocean on climate variability and change using a high resolution coupled model**
  - **New global coupled models: CM2.4, CM2.5, CM2.6, …**

Delworth et al. (2012)

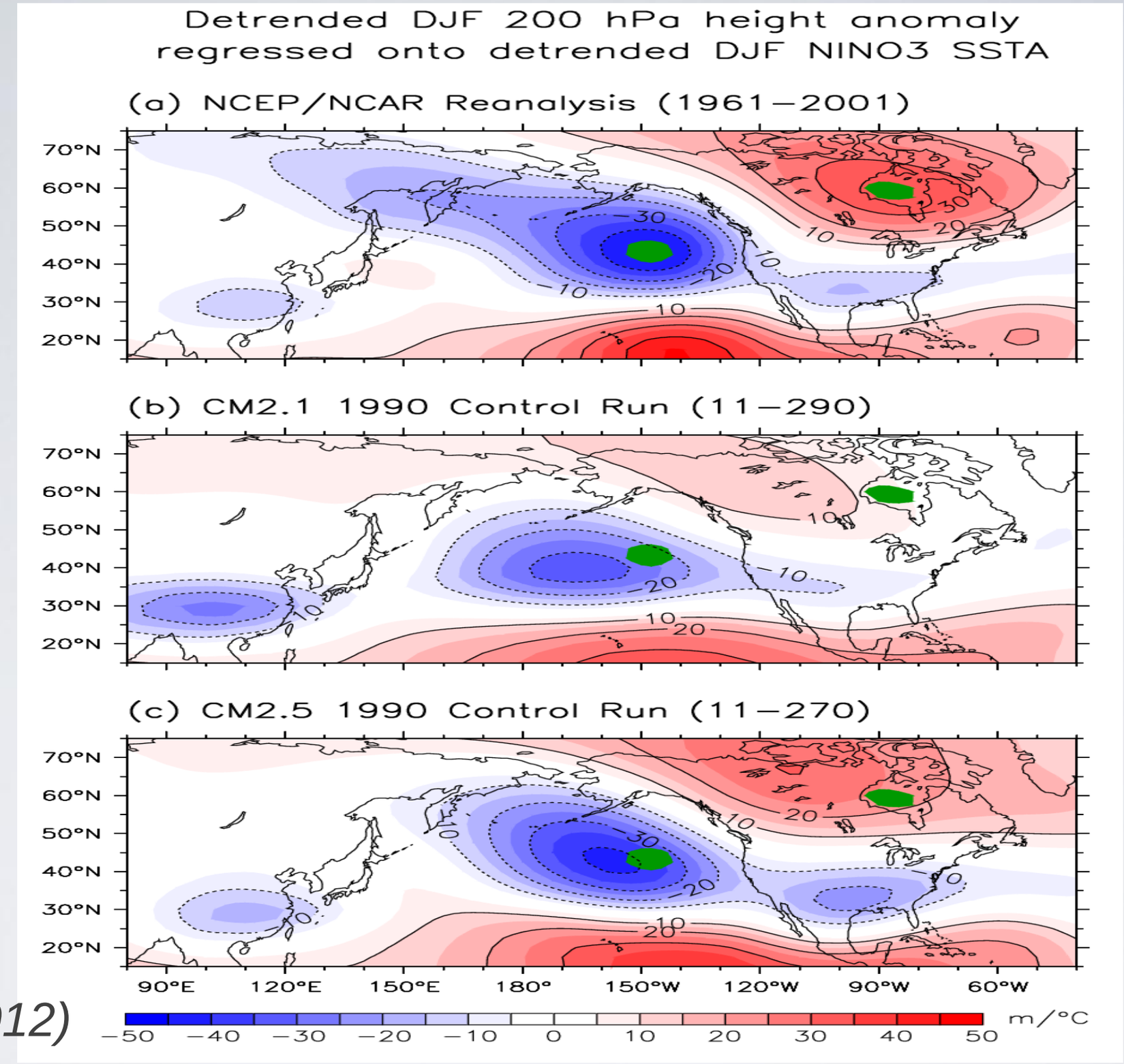
	Ocean	Atmos
CM2.1	100 Km	250 Km
CM2.3	100 Km	100 Km
CM2.4	10-25 Km	100 Km
CM2.5	10-25 Km	50 Km
CM2.6	4-10 Km	50 Km

GFDL-CM2.5 produces one of best global surface climate simulations of present model generation

Faster computer (GAEA) allows improved resolution that translates into significantly reduced biases in CM2.5 relative to CM2.1



Knutti et al. (2013)

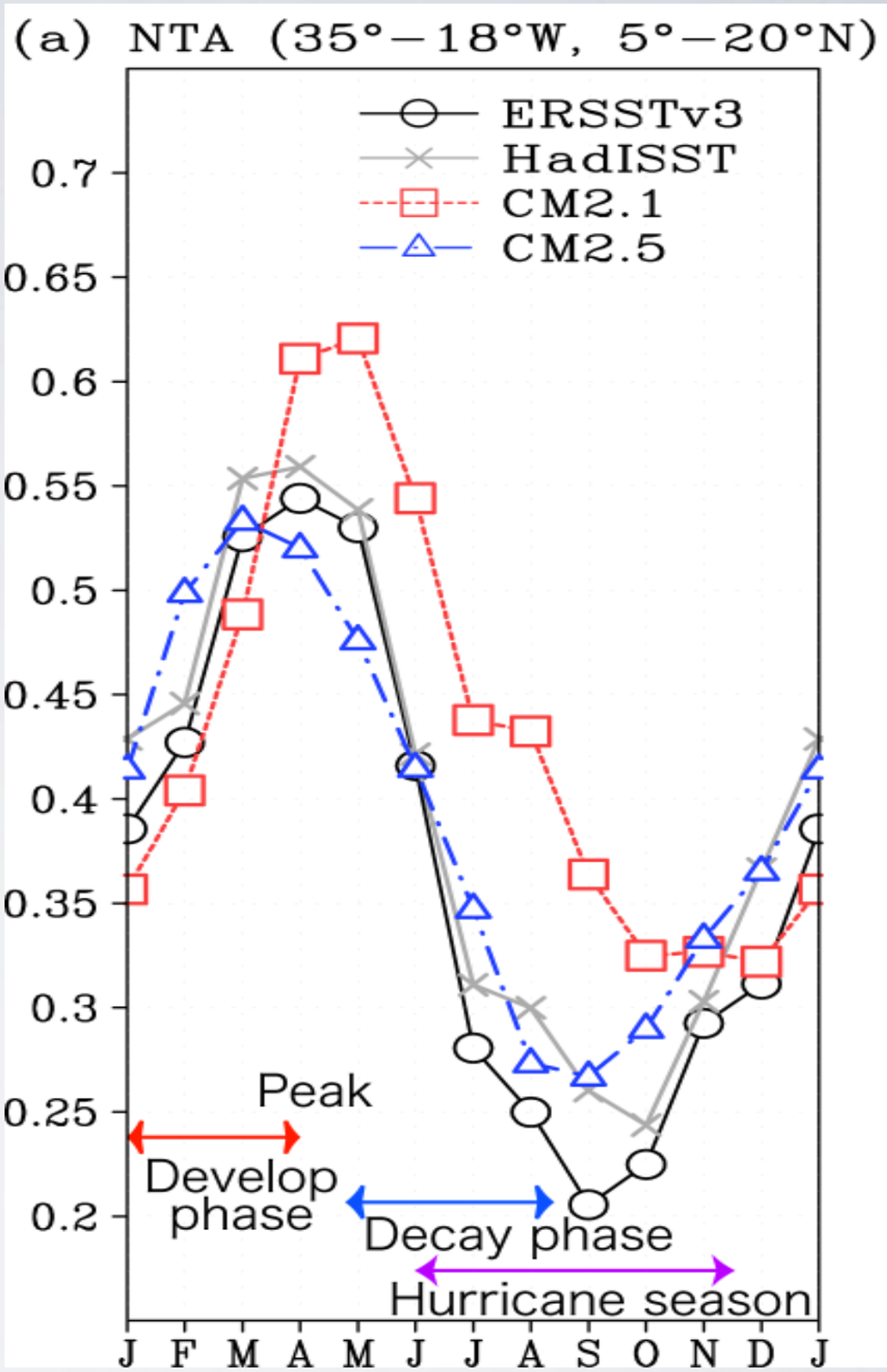


Delworth et al. (2012)

Figure 17 DJF 200-hPa geopotential height anomalies regressed onto DJF NINO3 SSTAs, computed using (a) the NCEP/NCAR Reanalysis (Kistler et al. 2001) for 1961-2001; (b) the CM2.1 1990 control run for years 11-290; (c) the CM2.5 1990 control run for years 11-0270. The zero contour is omitted. Green shading in all panels indicates the positions of the observed extrema over the North Pacific and Canada. Prior to computing the seasonal anomalies and regressions, all time series were detrended by removing a 20-yr running mean.

N. Tropical Atlantic climate improves from better Atlantic ITCZ simulation

Interannual N. Tropical Atlantic SST Standard Dev.



Doi et al. (2012)

Improvements in simulation of near-surface and atmospheric climate variability mainly tied to enhanced atmospheric resolution.

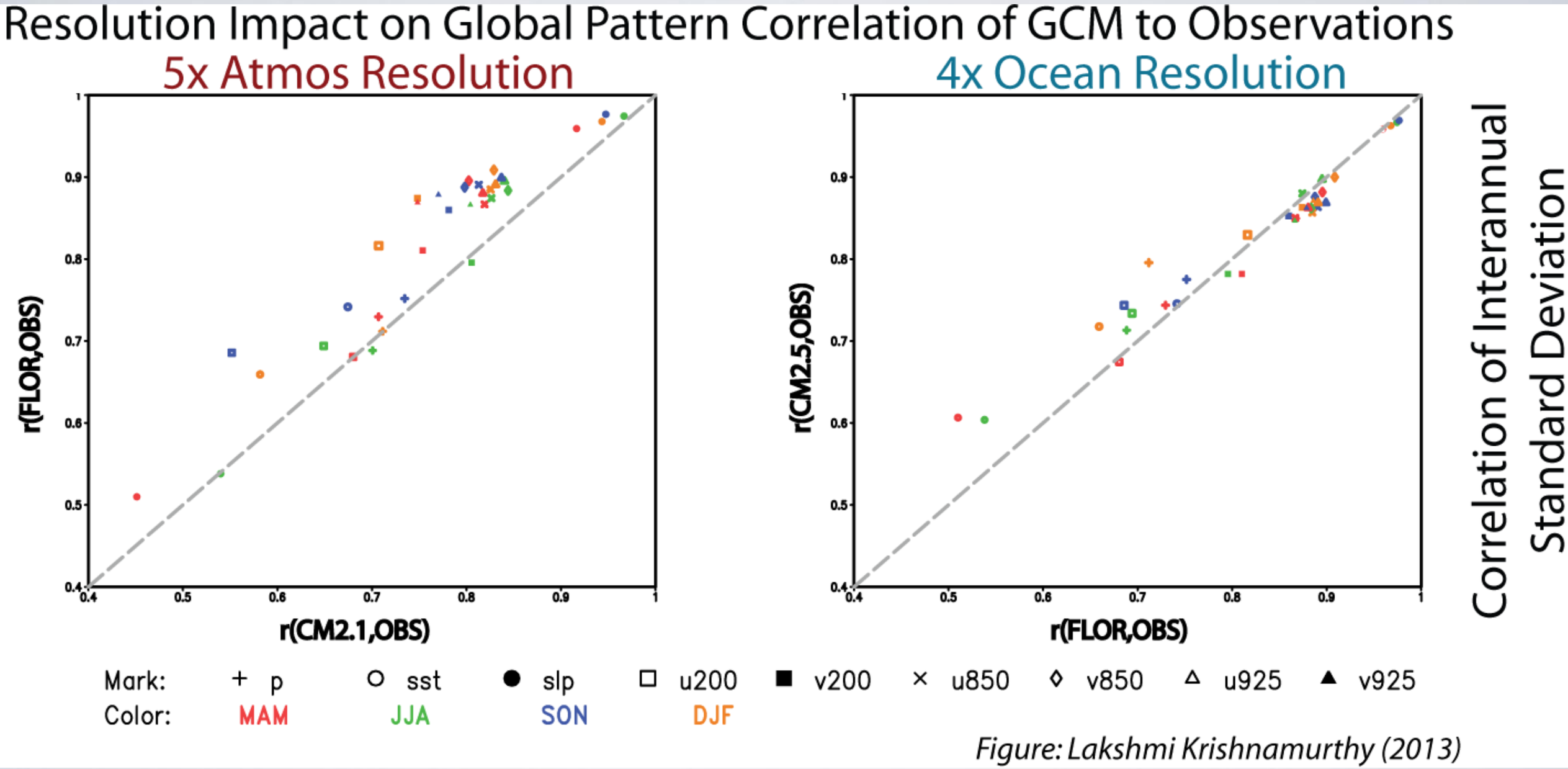


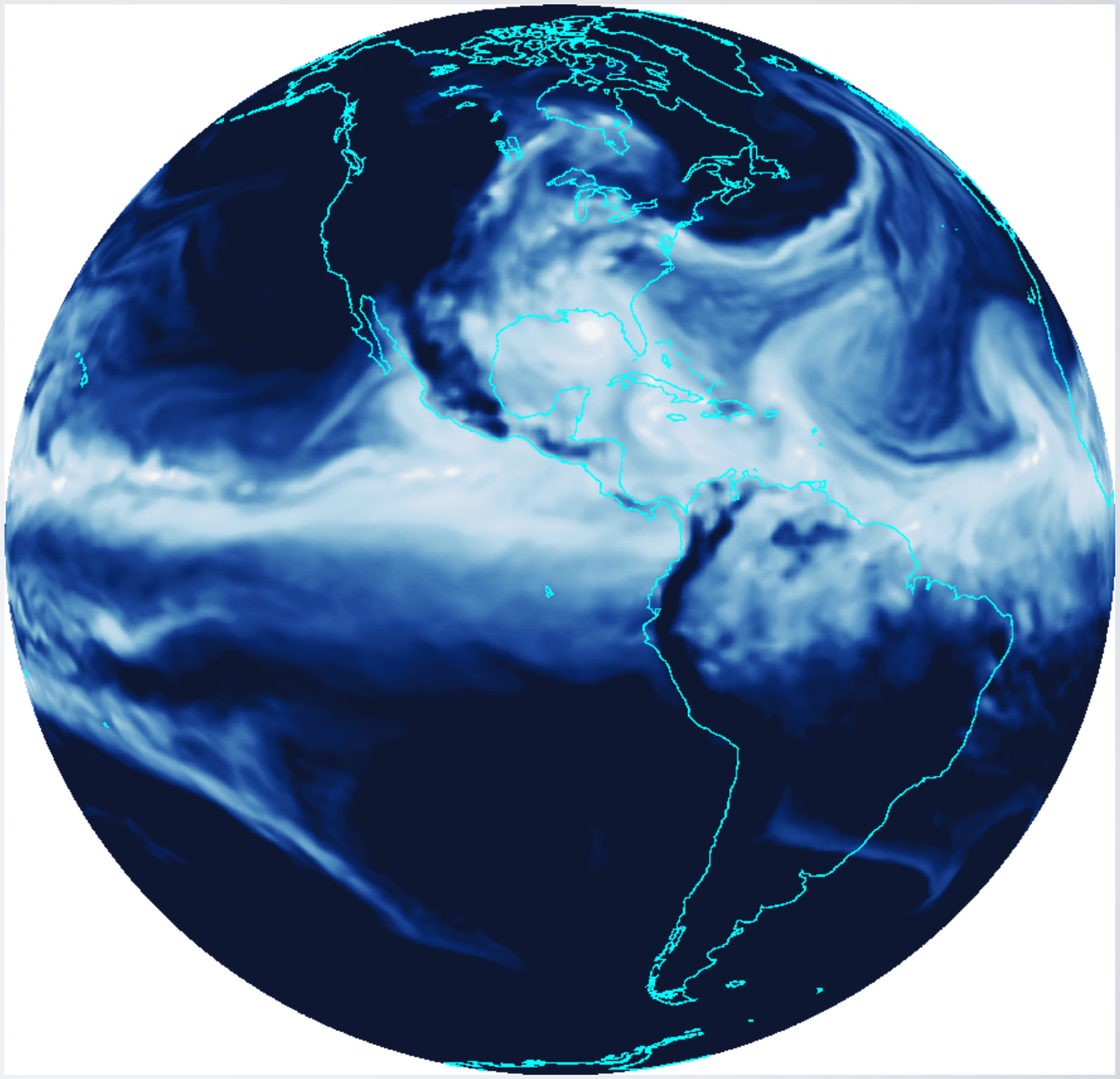
Figure: Lakshmi Krishnamurthy (2013)

High-resolution coupled prediction: FLOR

FLOR (Forecast-oriented Low Ocean Resolution version of CM2.5)

50km atm./land but with CM2.1's 1° ocean

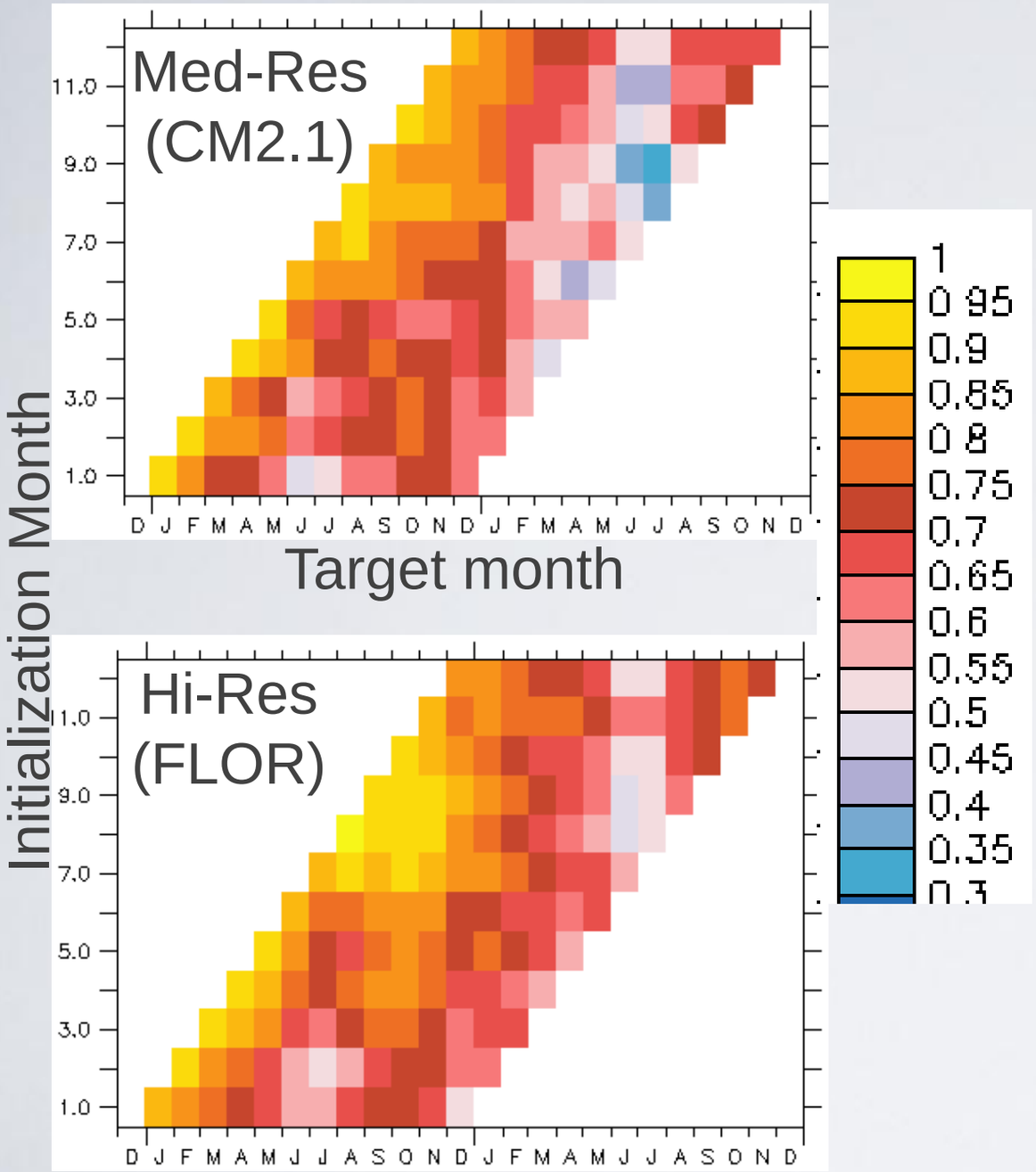
Modified Hypothesis:
Enhanced atmosphere & land resolution leads to improved simulation and prediction of climate – particularly regional and extremes.

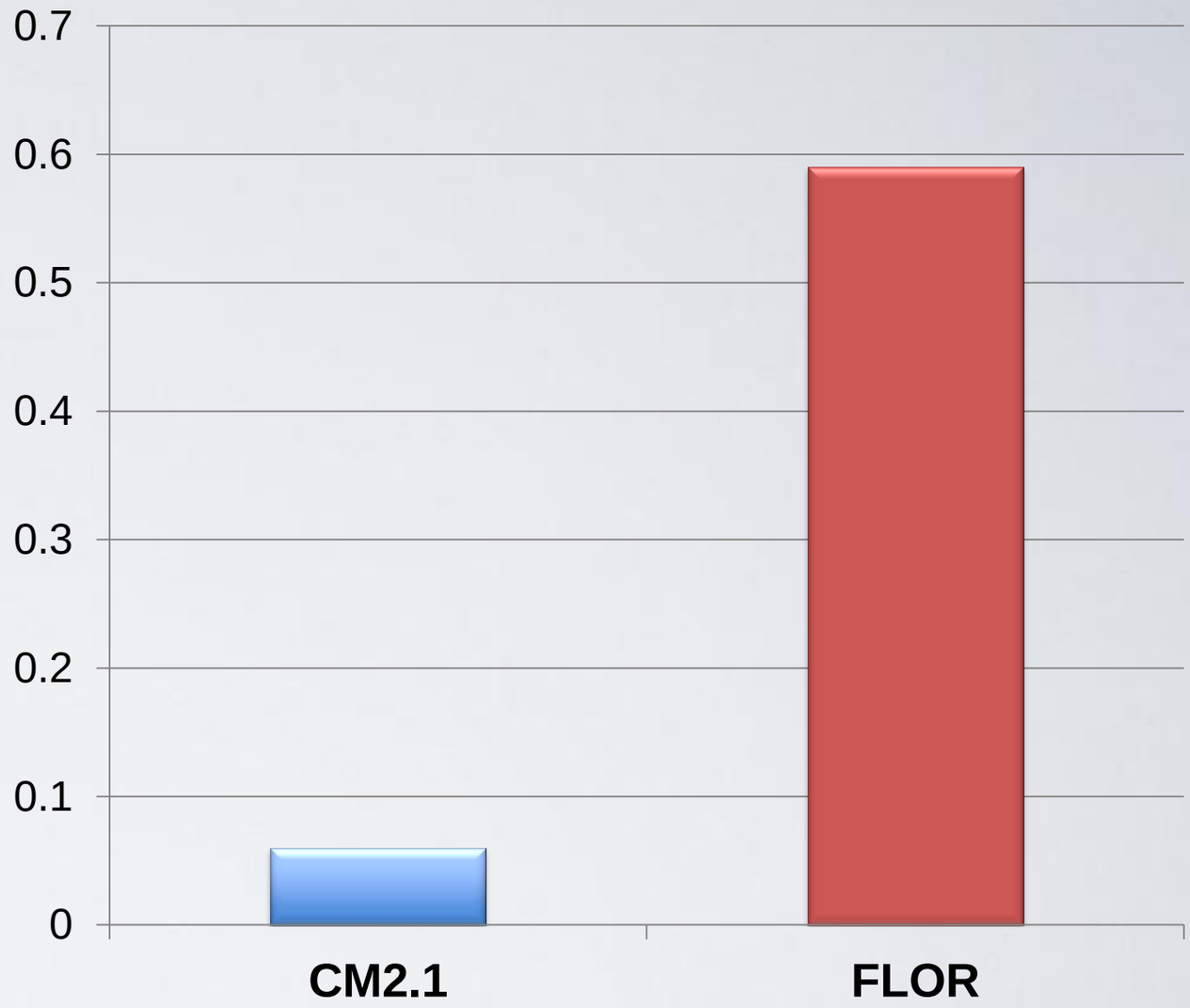


Snapshot of water vapor from FLOR forecast

Preliminary FLOR forecast results: Improved skill relative CM2.1
(both using CM2.1 I.C.s – not our "best shot")

Correlation 1982-2012 NIÑO3.4

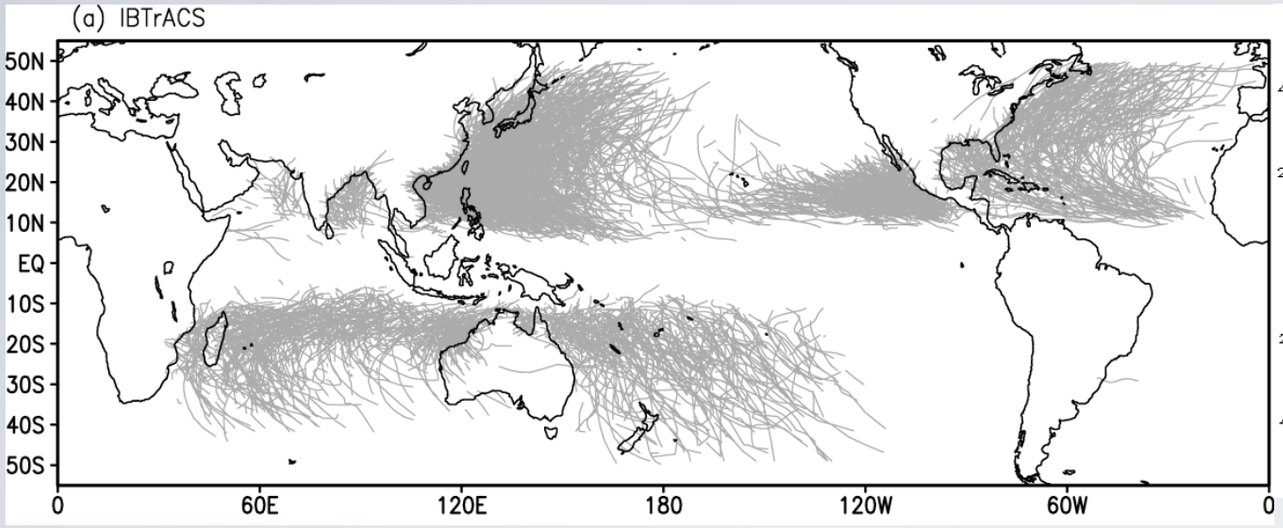




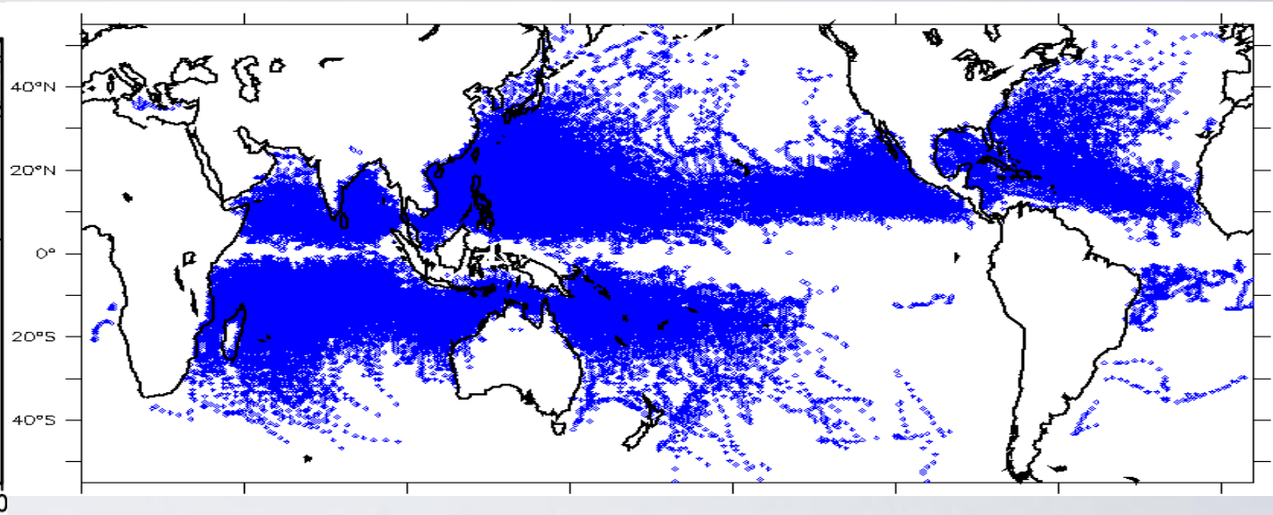
Increase in skill for global and regional surface temperature and precipitation over land (Liwei Jia et al. 2013, in prep.)

Towards seamless (or “lightly seamed”) seasonal-to-centennial TC changes in high-resolution global coupled models

Observed Tracks (30y)

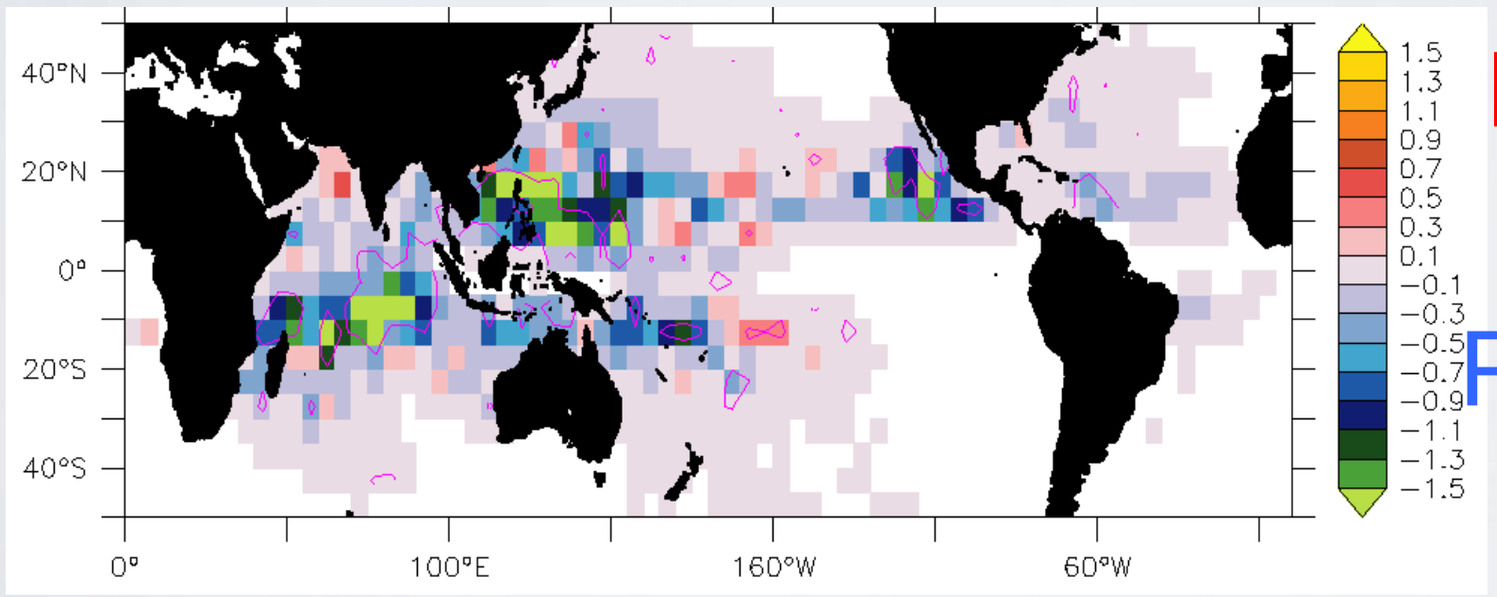


Coupled Model Tracks (30y actual seasonal forecasts



Vecchi et al. (2013, in prep.)

CM2.5 Tropical storm density response to CO_2 doubling

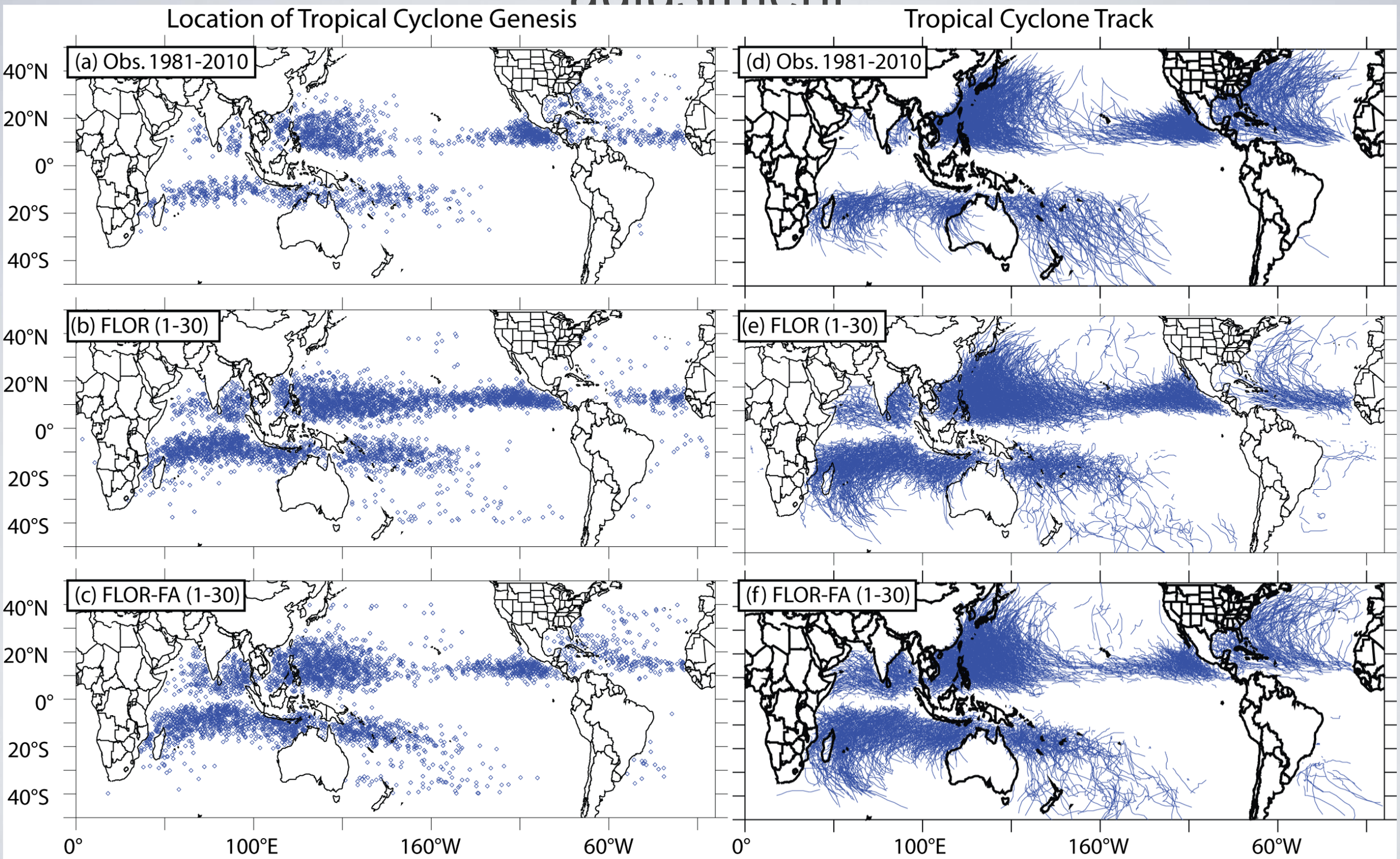


More storms

Fewer storms

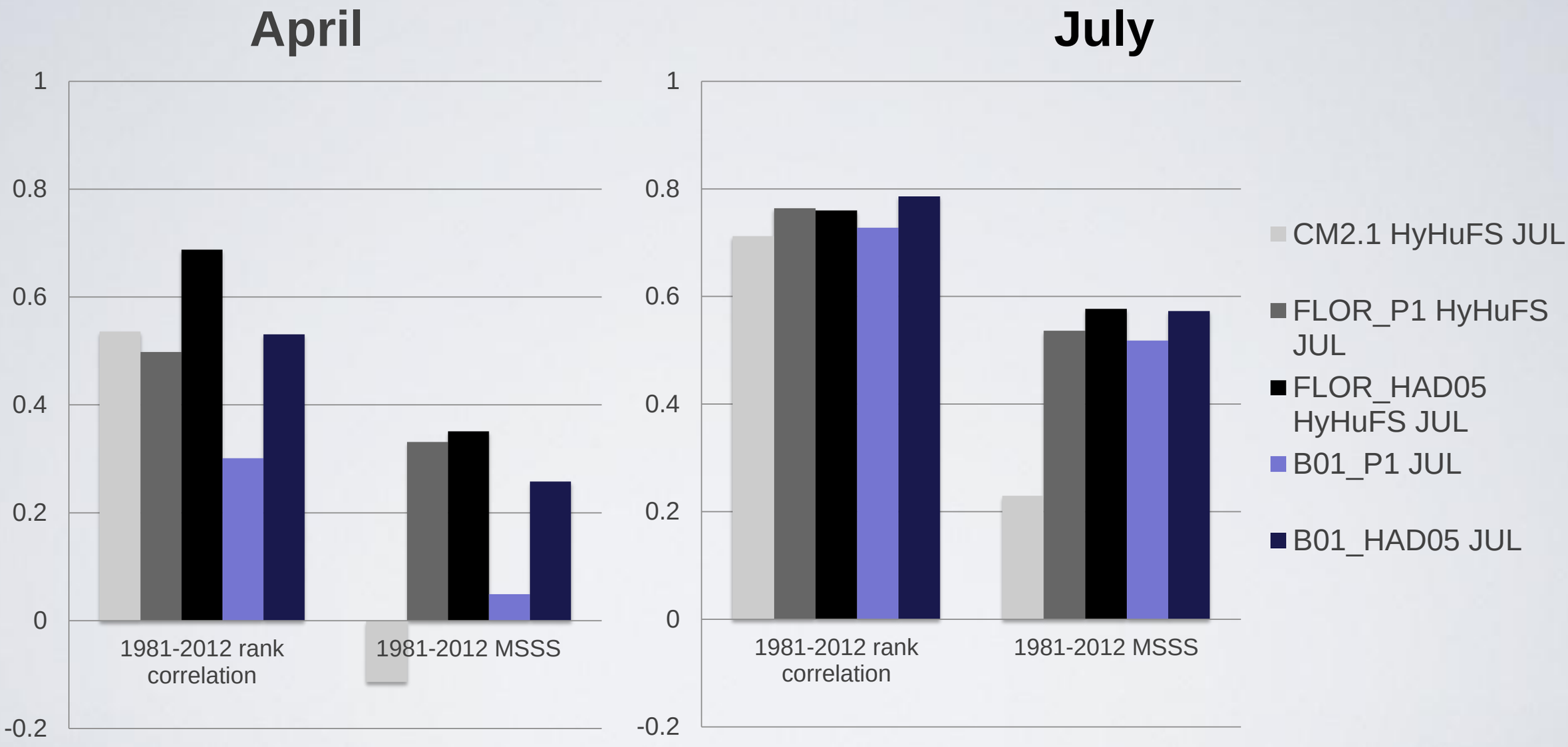
(Kim et al. 2013)

Coupled model TC tracks improved by flux adjustment



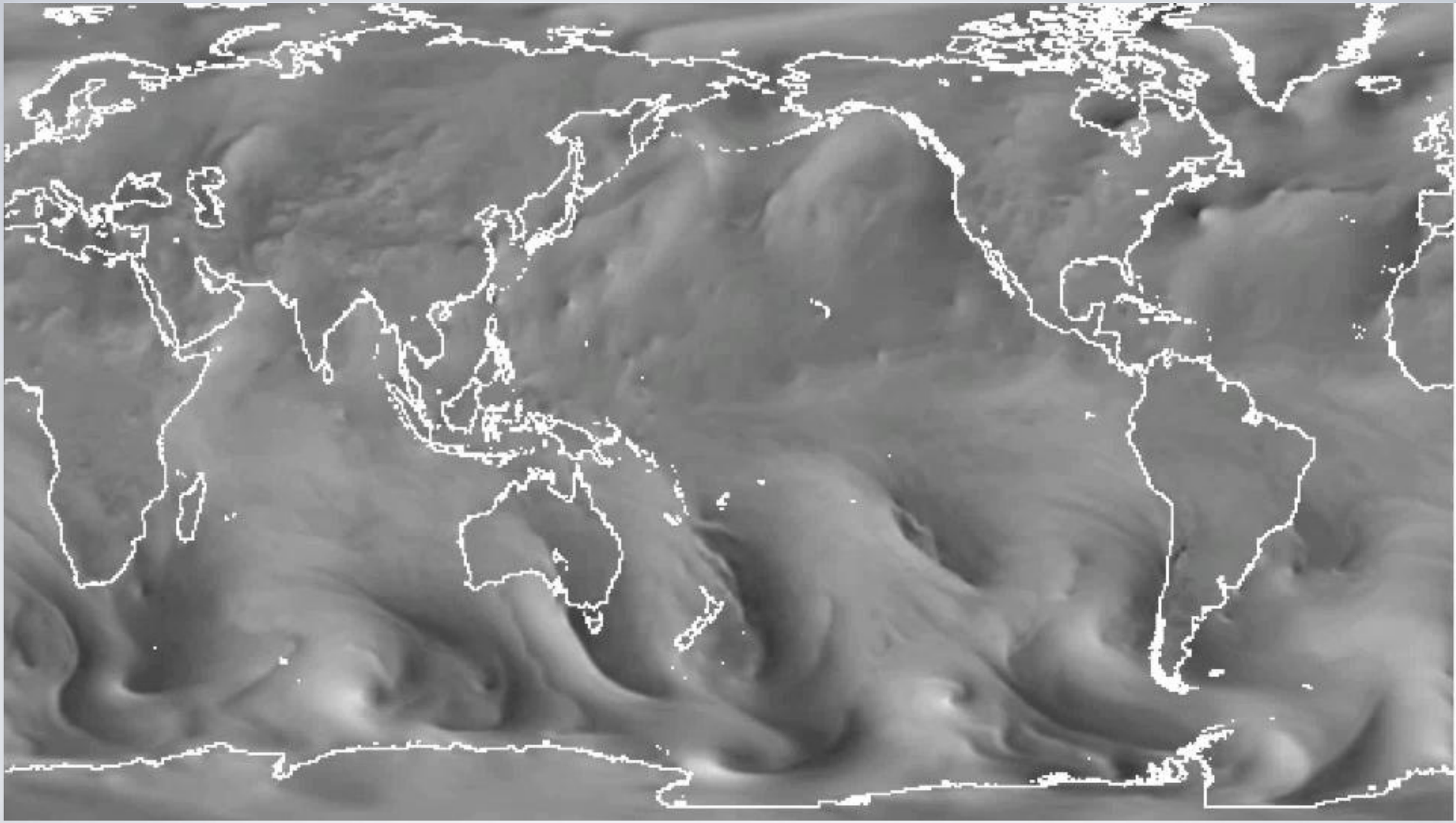
Vecchi et al. (2013, in prep.)

FLOR NA basin-wide TC predictions improve over CM2.1, Flux Adjustment Improves TC Predictions & Hybrid Statistical-Dynamical outperforms pure Dynamical



Vecchi et al. (2013, in prep.)

100 days of single ensemble of 1-Aug-2005 initialized CM2.5-FLOR 10-m v



4xdaily 1-Aug through 8-Nov 2005

Summary

- Hierarchy of dynamical models allow us to develop and enhance prediction of hurricanes on timescales from days to a century.
  - Seasonal-centennial TC predictions carry large inherent uncertainty, probabilistic predictions needed & large ensembles of dynamical predictions, or other way to estimate PDF.
- Enhanced computing enables the development of high-resolution coupled models to enhance prediction of water, storms and other extremes.
- Biases in large-scale climate simulation a key source of biases in simulation/prediction of regional climate and extremes.
- Hybrid statistical-dynamical predictions of TCs can outperform dynamical predictions for targeted predictands. Generally, statistical refinement improves even “good” predictions.